

IN THE CLAIMS

1. (currently amended) A lens for focusing an ultrasound wave having a wavelength, comprising a plurality of substantially concentric rings disposed about a central point, at least one of the rings having a substantially triangular cross-section defined by first, second, and third sections, the first section extending from a proximal end radially away from the central point to a distal end, the second section extending from the distal end of, and substantially perpendicular to, the first section and terminating at a peak, and the third section smoothly sloping from the proximal end of the first section to the peak of the second section, wherein the lengths of first sections of respective ones of the substantially concentric rings are less than about five wavelengths of the ultrasound wave and wherein the first, second and third sections have lengths with respect to the wavelength of the ultrasound wave such that (i) phases of the ultrasound wave are substantially additive at a focal point located on an axis perpendicular to the lens that passes through the central point, and (ii) aggregate focused ultrasound energy would not be predicted at the focal point by Snell's law refraction.

2. (original) The lens of claim 1, wherein the lens is formed substantially from polystyrene.

3. (original) The lens of claim 1, wherein the lens is formed substantially from crystal polystyrene.

4. (original) The lens of claim 1, wherein the third section slopes along a substantially straight trajectory from the proximal end of the first section to the peak of the second section.

5. (original) The lens of claim 4, wherein third sections of respective substantially concentric rings have smaller lengths as the respective substantially concentric rings are radially further from the central point.

6. (original) The lens of claim 5, wherein the slopes of the respective third sections are larger as the substantially concentric rings are radially further from the central point.

7. (original) The lens of claim 6, wherein first sections of respective substantially concentric rings have smaller lengths as the substantially concentric rings are radially further from the central point.

8. (original) The lens of claim 7, wherein:
the respective first sections of adjacent substantially concentric rings extend radially from the central point such that the distal end of the first section of an inner one of the adjacent substantially concentric rings terminates at the proximal end of the first section of an outer one of the adjacent substantially concentric rings; and

radii, r_i , extending from the central point to each of the distal ends of the first sections of the substantially concentric rings, adhere to the following equation:

$$(r_i^2 + F^2)^{1/2} \cong F + \lambda_f \cdot i,$$

where $i = 1, 2, 3, \dots$, F is a distance from a plane defined by the peaks of the substantially concentric rings to a focal point as measured along an axis normal to the plane, and λ_f is the wavelength of the ultrasound wave in a medium outside the lens.

9. (canceled).

10. (original) The lens of claim 1, wherein the third section slopes along a curved trajectory from the proximal end of the first section to the peak of the second section.

11. (original) The lens of claim 10, wherein:
respective first sections of adjacent substantially concentric rings extend along a radius, r , from the central point such that the distal end of the first section of an inner one of the adjacent substantially concentric rings terminates at

the proximal end of the first section of an outer one of the adjacent substantially concentric rings; and

third sections of respective substantially concentric rings are curved to substantially match respective segments of the following function of r :

$$(1/\lambda_f) \cdot ((r_1^2 + F^2)^{1/2} - F) \cdot (1/\lambda_f - 1/\lambda_{\text{lens}})^{-1},$$

where λ_f is the wavelength of the ultrasound wave in a medium outside the lens, and F is a distance from a plane defined by the peaks of the substantially concentric rings to a focal point measured along an axis normal to the plane.

12. (original) The lens of claim 1, wherein second sections of respective concentric rings have substantially equal lengths.

13. (currently amended) The lens of claim 12, wherein the lengths of the of the respective second sections are proportional to:

$$(1/\lambda_f) \cdot ((r_1^2 + F^2)^{1/2} - F) \cdot (1/\lambda_f - 1/\lambda_{\text{lens}})^{-1},$$

where λ_f is the wavelength of the ultrasound wave in a medium outside the lens, λ_{lens} is the wavelength of the ultrasound wave in the lens, and r_1 is the radius from the center point to the distal end of the first section of one of the substantially concentric rings.

14. (original) The lens of claim 13, wherein the lens includes a base having spaced apart first and second surfaces such that the base has a substantially uniform thickness between the first and second surfaces, and the substantially concentric rings are disposed on the first surface of the base such that the second sections of the respective substantially concentric rings extend from the first surface of the base away from the second surface of the base.

15. (original) A lens for focusing an ultrasound wave, comprising:

a base having spaced apart first and second surfaces and a central axis extending between the first and second surfaces; and

a plurality of substantially concentric rings disposed about the central axis and defining respective contours of the first and second surfaces of the base, the substantially concentric rings being sized and shaped such that, in cross-section, a plurality of concentric radially extending zones are defined from the central axis toward a periphery of the base, at least some of the rings having a substantially triangular cross-section such that a thickness of the base from the first surface to the second surface substantially smoothly increases with increased radial distance from the central axis within at least a portion of a given zone,

wherein the respective substantially concentric rings are sized and shaped such that (i) phases of the ultrasound wave are substantially additive at a focal point located on the central axis perpendicular to the lens, and (ii) aggregate focused ultrasound energy would not be predicted at the focal point by Snell's law refraction.

16. (original) The lens of claim 15, wherein the rings having a substantially triangular cross-section are defined by first, second, and third sections, the first section extending from a proximal end radially away from the central axis to a distal end, the second section extending from the distal end of, and substantially perpendicular to, the first section and terminating at a peak, and the third section sloping from a point substantially at the proximal end of the first section to the peak of the second section.

17. (original) The lens of claim 16, wherein each radially extending zone includes at most one ring from each of the first and second surfaces of the base.

18. (original) The lens of claim 17, wherein each radially extending zone includes only one ring from one of the first and second surfaces of the base.

19. (original) The lens of claim 18, wherein adjacent radially extending zones include rings from respective ones of the first and second surfaces of the base.

20. (original) The lens of claim 17, wherein each radially extending zone includes one ring from each of the first and second surfaces of the base.

21. (original) The lens of claim 20, wherein the respective contours of the first and second surfaces in each radially extending zone appear as mirror images of one another.

22. (original) The lens of claim 16, wherein the third section slopes along a substantially straight trajectory from the proximal end of the first section to the peak of the second section.

23. (original) The lens of claim 17, wherein third sections of respective substantially concentric rings have smaller lengths as the respective substantially concentric rings are radially further from the central axis.

24. (original) The lens of claim 23, wherein the slopes of the respective third sections are larger as the substantially concentric rings are radially further from the central point.

25. (original) The lens of claim 24, wherein first sections of respective substantially concentric rings have smaller lengths as the substantially concentric rings are radially further from the central axis.

26. (original) The lens of claim 25, wherein:
the respective first sections of adjacent substantially concentric rings extend radially from the central axis such that the distal end of the first section of an inner one of the adjacent substantially concentric rings terminates at

the proximal end of the first section of an outer one of the adjacent substantially concentric rings; and

radii, r_i , extending from the central axis to each of the distal ends of the first sections of the substantially concentric rings, adhere to the following equation:

$$(r_i^2 + F^2)^{1/2} \cong F + \lambda_f \cdot i,$$

where $i = 1, 2, 3, \dots$, F is a distance from a plane defined by the peaks of the substantially concentric rings to a focal point as measured along the central axis of the lens, and λ_f is the wavelength of the ultrasound wave in a medium outside the lens.

27. (original) The lens of claim 16, wherein the lengths of the first sections of respective ones of the substantially concentric rings are less than about five wavelengths of the ultrasound wave.

28. (original) The lens of claim 16, wherein the third section slopes along a curved trajectory from the proximal end of the first section to the peak of the second section.

29. (original) The lens of claim 28, wherein:

respective first sections of adjacent substantially concentric rings extend along a radius, r , from the central point such that the distal end of the first section of an inner one of the adjacent substantially concentric rings terminates at the proximal end of the first section of an outer one of the adjacent substantially concentric rings; and

third sections of respective substantially concentric rings are curved to substantially match respective segments of the following function of r :

$$(1/\lambda_f) \cdot ((r_1^2 + F^2)^{1/2} - F) \cdot (1/\lambda_f - 1/\lambda_{\text{lens}})^{-1},$$

where λ_f is the wavelength of the ultrasound wave in a medium outside the lens, and F is a distance from a plane defined by the peaks of the substantially concentric rings to a focal point measured along the central axis of the lens.

30. (original) The lens of claim 16, wherein second sections of respective concentric rings have substantially equal lengths.

31. (original) The lens of claim 30, wherein the lengths of the of the respective second sections are proportional to:

$$(1/\lambda_f) \cdot ((r_1^2 + F^2)^{1/2} - F) \cdot (1/\lambda_f - 1/\lambda_{\text{lens}})^{-1},$$

where λ_f is the wavelength of the ultrasound wave in a medium outside the lens, λ_{lens} is the wavelength of the ultrasound wave in the lens, and r is the radius from the center point to the distal end of the first section of one of the substantially concentric rings.

32. (original) The lens of claim 15, wherein the lens is formed substantially from polystyrene.

33. (original) The lens of claim 15, wherein the lens is formed substantially from crystal polystyrene.

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70. (original) A lens for focusing an ultrasound wave having a frequency f and a wavelength λ_m in a medium having an acoustic velocity v_m , the lens comprising a body formed from a material having acoustic velocity v_1 different from v_m , the body having an axis, front and rear surfaces transverse to the axis, and radial directions r_i perpendicular to the axis, the body varying in thickness in the radial directions so as to define a plurality of rings concentric with the axis on at least one of the surfaces, each ring having an outer wall substantially parallel to the axis and a smoothly sloping active wall extending radially and axially so that the thickness of the lens varies progressively in the radial direction within each ring substantially according to the formula:

$$(f/V_m) \cdot ((r_1^2 + F^2)^{1/2} - F) \cdot (f/V_m - f/V_1)^{-1},$$

where F is a distance from the axis to a focal point located along the axis away from the lens.

71. (original) A lens as claimed in claim 70 wherein all of the active surfaces are disposed on the rear surface of the lens.

72. (original) A lens as claimed in claim 70 wherein the body is substantially planar and extends in a plane perpendicular to the axis.

73. (original) A lens as claimed in claim 70 wherein the active surfaces are substantially conical and the thickness of the lens varies with radius according to a linear approximation of the formula.

74. (original) A lens as claimed in claim 73 wherein the linear approximation is selected so that the thickness of the lens at the innermost and outermost edges of each active surface is equal to the thickness according to the formula.